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CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

TECHNICAL ADVISORY COMMITTEE

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PROGRESS REPORT

ON THE

INTER-CENTRE REVIEW OF ROOT AND TUBER CROPS RESEARCH

IN THE CGIAR

(Agenda Item 6)

TAC SECRETARIAT

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

June 1995

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June 20, 1995

Dr. Donald L. Winkelmann
Chairman
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Food and Agriculture Organization
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Dear Dr. Winkelmann,

It is my pleasure to transmit to you the Progress Report of the Inter-Centre Review of Root and Tuber Crops Research in the CGIAR.

This has been a particularly challenging assignment, and I have been delighted with the enormous cooperation by the participating International Agricultural Research Centres. As you are no doubt aware, the timing for this Inter-Centre Review was planned to closely follow the External Program and Management Reviews of the CIP, CIAT, and IITA. The clearly evident advantage of this timing was to draw upon the wealth of knowledge and depth of evaluation surrounding these EPMRs, and to build upon that experience with an Inter-Centre Review of Root and Tuber Crops Research within the CGIAR.

The timing of the July 10-15, 1995 TAC meeting required that the Inter-Centre Review meet a carefully planned timetable for document delivery. Otherwise, we understand, our progress report's presentation would have to be delayed until the December 1995 meeting of TAC.

We have met our goals through a confluence of extra effort and outstanding cooperation by all participants.

Under the terms of reference provided by TAC, we convened a workshop of individuals representing perspectives, interests, and experience appropriate to the Inter-Centre Review. The three-and-one-half day workshop was held at the University of Maryland in late May and early June, and was facilitated by Mr. Donal O'Hare, of O'Hare Associates, Inc. This format permitted the exploration of a number of priority issues in a setting that allowed the standing panel to have direct interaction. This proved to be an extremely effective approach to the assignment set out in your terms of reference.

Immediately following the workshop, the standing panel drafted its progress report, which was then shared with all workshop participants *via* Internet. Our purpose for conducting an open review was to develop consensus and "buy-in" to the analysis and recommendations presented in our progress report. As noted during the workshop and in our report, the purpose of the exercise was not to provide proceedings of the workshop, but to extract information for the panel's use in deriving its recommendations.

As a consequence of the quick turnaround caused by our self-imposed deadlines, I assume full responsibility for any errors or misrepresentations contained in this progress report. The standing panel has not had an opportunity to review this advanced draft. I could, however, find no alternative beyond my assuming responsibility for this final version if our timeline was to be met.

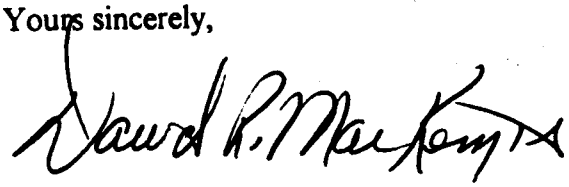
Contained in our report is a fundamental recommendation to create an Inter-Centre Consultative Committee on Root and Tuber Crops Research. This Committee would be charged with exploring the commonalities of the root and tuber crops as a basis for inter-Centre research collaboration opportunities. Our report lists some of these similarities, and offers encouragement to the Centres to pursue the synergy that we believe could be derived from enhanced collaborative research efforts. We do caution, however, that the dissimilarities of root and tuber crops are extensive, and not as conspicuous as some would presume. It is for this reason that we have carefully tailored a set of subsequent recommendations that we believe are soundly based in scientific opportunities for these important commodities.

I draw your attention to the widely-held belief, noted in our report, that root and tuber crops research within the CG System is disadvantaged in the TAC priority setting process. This perception has been attributed by some to bias and misunderstandings that should be addressed and resolved before the next round of TAC priority setting.

I also draw your attention to the relative absence of treatment in our progress report of the topics of sustainable agriculture and natural resource management research. This is not oversight on the standing panel's part, but is a consequence of our inability to identify commonailities for the crops in these areas of study. This point may, however, deserve further analysis.

In closing, I would like to express the standing panel's sincere appreciation for the substantial support that we received from the participating IARCs and the TAC Secretariat for this Inter-Centre Review. The standing panel is particularly aware of the acute staff difficulties experienced by the TAC Secretariat during the period of this review, but, in spite of these difficulties, their timely and professional support was rendered on all occasions. I look forward to discussing our progress report with you at the July TAC meeting, and to receiving instructions from you on the next steps to be taken, if any.

Yours sincerely,



DAVID R. MacKENZIE, Chair
Inter-Centre Review Standing Panel

CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

TECHNICAL ADVISORY COMMITTEE

PROGRESS REPORT

ON THE

INTER-CENTRE REVIEW OF ROOT AND TUBER CROPS RESEARCH

IN THE CGIAR

Panel: David R. MacKenzie (Chair)
Evert Jacobsen
Donald Plucknett
Carlos Sere

TAC SECRETARIAT

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

June 1995

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PREFACE

1. This is a progress report of the Inter-Centre Review of Root and Tuber Crops Research in the CGIAR. The standing panel membership for this Inter-Centre Review were Drs. Evert Jacobsen, David R. MacKenzie, Donald Plucknett, and Carlos Sere. Their addresses can be found in Appendix 1 of this report.

2. The detailed terms of reference for this Inter-Centre Review are shown in Appendix 3. The panel's approach to this Inter-Centre Review was been an open, participatory, issues-based investigation of the opportunities for Inter-Centre research collaboration on the root and tuber crops mandated within the CG system. The timing for this Inter-Centre Review was planned to closely follow the External Program and Management Reviews (EPMR) of the International Agricultural Research Centers (IARC) engaged in root and tuber crops research (CIP, CIAT, and IITA). The process that was used by the standing panel was a three-and-one-half day workshop, held at the University of Maryland, May 30 - June 2, 1995, with participation from selected members of the root and tuber crops research community having experience relevant to the topics being studied. Representatives from five IARCs, several international consultants, some research management experts, and a meeting facilitator provided the panel with extraordinarily rich source of information for the review.

3. The standing panel also had access to extensive documentation developed for the three EPMRs, as well as specifically drafted documents prepared by the participating Centres, entitled, "Issues and Options Papers" (see Appendix 2). In these papers, the Centres provided description of the purpose and the extent of collaboration by discrete activities; research collaboration mechanisms; benefits accrued to the Centre and the system as a whole from the collaboration; suggestions as to what further inter-Centre strategies might be captured in future collaborative projects; and suggestions on how best to promote and initiate more effective inter-Centre collaboration on roots and tubers research. Centres were also asked to provide documentation on the impact and benefits of root and tuber crops research, *ex ante* and *ex post*, and to evaluate their institutional comparative advantages *vis a vis* non-CGIAR institutions. Other topics requested of the participating Centres were evaluations of existing structural efficiency, and any perceived advantages and disadvantages of restructuring research staff, facilities, and services in support of current and future root and tuber crops research in the CGIAR. The primary goal of the latter point was to look at gaining greater efficiency of CGIAR investments in root and tuber crops research. Finally, the participating Centres were invited to provide expressions of program priorities and their views on the likely consequences of reducing or eliminating some ongoing or planned program activities that they judged to be of lower priority.

4. The perspectives derived from this documentation and from the participation in the workshop were used by the standing panel to evaluate issues, analyze options, and develop recommendations for this progress report. The study did not undertake any country field visits, inasmuch as these perspectives were provided through the experience of participation in the EPMRs.

5. One acknowledged weakness of the process was the lack of representation by National Agricultural Research System (NARS) scientists. This omission was a conscious decision, based on the following rationale.

6. Extensive contact with NARS scientists was provided through the three EPMRs, with each review particularly focused by their terms of reference on opportunities for partnership and for devolution of research programs. This information was used as a resource by the panel in evaluating various options in this Inter-Centre Review. The panel believes, therefore, that NARS perspectives have been adequately included in this progress report. The panel anticipates that subsequent steps of this Inter-Centre Review may include evaluation of the recommendations by NARS representatives. This would, then, "close the loop" through a broader representation of NARS than would have been possible by including a very limited number of NARS scientists in the Root and Tuber Crops Research workshop.

7. Altogether, the standing panel believes that it has been able to obtain information, documentation, and perspectives sufficient that it can forward with confidence the analysis and recommendations contained in this progress report. The panel hopes that this report will be useful to TAC in evaluating root and tuber crops research in the CGIAR.

SUMMARY AND RECOMMENDATIONS

8. This is a progress report of the standing panel commissioned by the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR) to conduct an Inter-Centre Review of Root and Tuber Crops Research within the CGIAR. The terms of reference provided by TAC were to assist TAC in formulating a system-wide strategy for research on root and tuber crops within the CG System to meet global and regional needs, taking into account current and projected demands. The standing panel was given specific guidance for assessing priorities and the organization of research, giving consideration to root and tuber crops as both commodities and as components of production and farming systems. The terms of reference asked the standing panel to explore alternative approaches for carrying out this work, with special consideration to be given to major constraints on increased production and consumption of these commodities. This included post-harvest problems, with emphasis on those topics with international research significance. The standing panel was also asked to outline priorities and strategies for root and tuber crops research within the CGIAR, paying particular attention to system-wide aspects of research efficiency and impact potential.

9. The timing of the Inter-Centre Review was specifically selected to follow the External Program and Management Reviews of the three International Agricultural Research Centers with mandates to conduct research on root and tuber crops (CIP, CIAT, and IITA). The standing panel was comprised of specialists knowledgeable in the specific research activities of the three IARCs and of international activities in root and tuber crops research.

10. The Inter-Centre Review employed a workshop forum that was professionally facilitated and attended by representatives of five IARCs (CIP, CIAT, IITA, IPGRI, and IFPRI), research specialists in production and post harvest technology, research managers, and consultants with experience relevant to the review topics. The workshop was held on the campus of the University of Maryland, May 30 - June 2, 1995, and was supplemented by substantial documentation derive from the three EPMRs, as well as reports specifically prepared for the Inter-Centre Review (see Appendix 2).

11. Six issues were identified for the standing panel, based on discussions at the root and tub crops workshop. These six issues were:

- Global planning and organization within the CG System
- Germplasm and vegetative propagation
- Biotechnology research
- Post-harvest and market research
- Partnerships
- Policy research

12. The panel has summarized its findings and judgements in the form of answers to questio that are followed by the recommendations contained in this report.

Are the CGIAR priorities appropriate to research on root and tuber crops?

13. The panel separated this question into three dimensions for its analysis:

- root and tuber crops research as a component of total CG commitments
- individual crops as priorities within the CG mandated root and tuber crops
- types of research to be undertaken (e.g., post-harvest, biotechnology).

14. Regarding the first dimension (root and tuber crops as a component of the CG system), the panel observed that there is considerable disagreement with the TAC priority setting process that some Centre scientists feel unjustifiably discounts root and tuber crops, relative to grain crops. In the panel's judgement, there is a strong need to reconcile these alleged differences before TAC begins another round of priority setting.

15. Regarding the relative priorities of individual crops within the mandated root and tuber group, the panel concluded that modest downward readjustments in emphasis are indicated for yam and sweet potato to permit increased activities in research on cassava and potato. This judgement is based on the panel's assumption that significantly greater resources will not be made available for expanded research programs. However, given the clear need to expand research activities in cassava and potato, some concomitant downsizing seems appropriate, in the panel's view. This downsizing could occur through reassignment of research responsibilities to research-strong NARS. Likely candidates would be sweet potato to China and yam to Nigeria. The standing panel notes that neither the sweet potato nor the yam research programs could be currently characterized as comprehensive, and the modest reductions proposed by the standing panel seem appropriate to the priorities and strategies of TAC.

16. The panel evaluated extensively the need for different types of research on root and tuber crops from the perspective of Inter-Centre collaboration. The standing panel identified similarities and dissimilarities of the of the mandated root and tuber crops of the CG System. This distinction permitted the identification of research activities that could be Inter-Centre collaborations across root and tuber crops with anticipated benefits through program synergy. Some examples of these research areas are:

- Post-harvest technology and market research
- Biotechnology
- Policy analysis
- Vegetative propagation and conservation technology
- International germplasm exchange with phytosanitation
- Collection of statistics and surveys
- Training
- Mechanization research

Are the current Centre mandates for root and tuber crops appropriate?

17. The standing panel explored this question extensively, and concluded that readjustments to the Centre's mandates are not justified at this time. Considerable discussion was given to designating a lead Centre for cassava germplasm conservation, but persuasive arguments advanced by both CIAT and IITA showed this would serve no purpose, as the existing mandates are adequate, and are working well. For this reason, the standing panel makes no recommendation for change to the existing Centre mandates for root and tuber crops.

Are the current strategies for inter-Centre research working?

18. The panel was not able to identify a clearly stated inter-Centre strategy for research on root and tuber crops. However, in its analysis, the panel was able to determine that certain types of root and tuber crops research are more appropriate to inter-Centre research activities than are other types. In the panel's analysis, there are three types of root and tuber crops research that need to be accommodated in a strategy for inter-Centre research. These distinctions are related to the similarities and dissimilarities of root and tuber crops, which are not always apparent.

19. **Type 1:** The dissimilarities of root and tuber crops that are identified in the progress report clearly established the justification for research independence for the mandated root and tuber crops in many areas. These independent research activities should continue as presently organized. Attempting to force inter-Centre collaboration on dissimilarities of the root and tuber crops would offer no benefit.

20. **Type 2:** There is, however, a considerable number of opportunities for inter-Centre research collaborations that are, or could be, based on the identified similarities of root and tuber crops. This progress report provides an analysis of these similarities, with recommendations for their facilitation.

21. **Type 3:** The third category of research identified by the standing panel includes projects of cross-cutting, system-wide natures, that include root and tuber crops but also extend to other commodities as well. One example of system-wide research opportunities is Integrated Pest Management. The panel did not address this type of research in its recommendations, as it clearly extends beyond the boundaries of the standing panel's terms of reference.

Are there alternative mechanisms that could be used to facilitate inter-Centre collaboration?

22. The standing panel gave considerable attention to alternative mechanisms that would "reengineer," "reorganize," or "reassign" research responsibilities, and concluded that major changes to the research structure are not justified at this time. The standing panel's preferred strategy would be to create an Inter-Centre Consultative Committee on Root and Tuber Crops Research that would facilitate inter-Centre research activities as a coordinating mechanism. This

recommendation was formulated by the standing panel as the overarching recommendation for this progress report. The standing panel prefers this "gentle hand" approach to inter-Centre collaboration, and feels that it is more appropriate to the opportunities and needs of the Centres mandated to research the root and tuber crops. This judgement is based on the example of the excellent collaboration that currently exists between IITA and CIAT for cassava research. Both Centres actively seek to bring the right people together on the right research topics in consultative approaches.

Are there opportunities for greater interactions with Advanced Research Organizations and National Agricultural Research Systems?

23. The standing panel clearly envisioned many opportunities for expanded activities of inter-Centre collaborations to partner with other public and private institutions in both the developed and developing countries. In fact, the standing panel views this dimension of the proposed facilitation of inter-Centre research projects as a great strength, and as highly desirable.

RECOMMENDATIONS

The panel recommends that an Inter-Centre Consultative Committee on Root and Tuber Crops Research be formed for system-wide planning, coordination, and operation.

The panel recommends that the proposed Inter-Centre Consultative Committee:

- **Commission a task force to explore the possibility of rationalizing international phytosanitation regulations and institutional arrangements for shipments of root and tuber crops as vegetatively-propagated materials.**

- **Commission a study to recommend inter-Centre collaborations in biotechnology research.**

- **Sanction a post-harvest technology and market working group to explore with AROs, NARS, and the private sector root and tuber crops research partnerships on:**

  - **The characterization of starch and flour (antecedent to industrial processing).**
  - **Food processing technology.**
  - **Market research.**

- **Continuously explore opportunities for different types of partnerships and collaborations among IARCs, and with public and private partner institutions in both the developed and developing world.**

- **Convene a task force, including non-CG members, to prepare a comprehensive, documented text that sets out a vision for root and tuber research employing inter-Centre collaborations and institutional partnerships for root and tuber crops.**

PROGRESS REPORT
INTER-CENTRE REVIEW OF ROOT AND TUBER CROPS RESEARCH IN THE CGIAR

SECTION 1 - INTRODUCTION AND BACKGROUND

24. At ICW93, the Consultative Group on International Agricultural Research (CGIAR) requested its Technical Advisory Committee (TAC) to initiate a critical examination of CGIAR programs in the context of a long-term vision, taking into account current and future trends with options for structural change within the system. A derivative of this examination was a paper tabled at the Mid-term meeting in May 1994, in New Delhi, India, entitled, "The CGIAR in the 21st Century: Options for Structural Change." In this paper, TAC noted trends in root and tuber crops production and consumption, globally and by region, and put forth the "urgent need to define a CGIAR strategy for roots and tubers research in the medium term and to explore alternative institutional mechanisms."

25. This conclusion was based on several assumptions stated by TAC:

- Root and tuber crops are subsistence crops of critical importance to low-income producers and consumers.
- These crops are subject to declining demands as incomes rise (panel comment: this is probably true for sweet potato, but not for potato, yam, or cassava products).
- Biologically, these crops have many similar characteristics, such as: vegetative propagation; their susceptibility to some pests and viral diseases; and their perishability, which makes post-harvest work important. The research disciplines that provide inputs into roots and tubers research are therefore similar.

26. The paper then noted, "Because of potential reduced priority of cassava, potato, and sweet potato in the future and the emergence of alternative sources of research supply, the scale of future CGIAR efforts in research on these commodities could be lower than it is today ... To this end TAC is conducting a stripe review of research on roots and tubers to further explore these issues."

1.1 Terms of Reference

27. The Inter-Centre Review of Root and Tuber Crops Research (hereinafter called the Inter-Centre Review) in the CGIAR was commissioned for the purpose of assisting "TAC in formulating a system-wide strategy for research on roots and tubers in the CGIAR to meet global and regional needs, taking into account current and projected demands." The so-called "stripe review" was, by its terms of reference, specifically to address CGIAR priorities and the organization of work, and to explore alternative approaches for carrying out this work. The

review was to be done in consideration of major constraints in the production and consumption of root and tuber crops, and ongoing research and related activities within the CG system and elsewhere.

28. Consideration was also to be given to priorities and strategies within the CGIAR, with particular attention to system-wide aspects of research efficiency and impact potential. Attention was to be given to existing and preferred collaboration, impacts, and benefits of Centre activities, comparative advantages, structural efficiencies, and program priorities from an inter-Centre perspective (see Appendix 3 for the complete Terms of Reference for this review).

29. The Inter-Centre Review panel (see Appendix 1 for the membership) accepted the charge from TAC with the understanding that the timing had been selected to follow EPMRs of CIP, CIAT, and IITA. which would provide a foundation of analysis and information for the Inter-Centre Review. To this end, three consultants who had directly participated in one or more of the EPMRs were asked to serve on the standing panel, with the chair of the CIP EPMR.

1.2 Review of CGIAR Priorities and Strategies

30. The TAC Secretariat published, in December, 1994 a document entitled, "Review of CGIAR Priorities and Strategies." In this document, it was noted that the CGIAR has the ability "to continuously adapt to changing circumstances (which) should be seen as a strength ..." This statement followed the observation that "TAC's review of activity balance, regional distribution of resources, and commodity congruence suggested that the 'founding fathers' of the CGIAR and its changing membership since have charted a course that allows for evolution and change, and continues to address high priority issues."

31. Specific to root and tuber crops, TAC recommended maintaining current efforts in cassava, sweet potato, potato, and yam, with the last commodity being reviewed for research effectiveness in the "next external review of IITA, which has the global mandate for this commodity."

32. Additionally, TAC noted the divergence between modified value of production and CGIAR allocations. "Nevertheless, TAC recommends maintaining current efforts in cassava and other root and tuber crops." Later on in the document, it was stated that, "TAC reaffirmed the priority it is currently allocating to the cereal and root and tuber crops," suggesting a linkage in priority setting between cereal crops and root and tuber crops.

33 The preceding information is important as background in understanding the approach and process that were used for conducting this Inter-Centre Review. During the EPMRs repeated reference was made to the review panels of misunderstandings and misperceptions regarding the

appropriate priority and relevant strategy for the root and tuber crops research within the CG System. Given these stated concerns, it seemed appropriate for the Inter-Centre Review panel to involve appropriate IARC representation.

1.3 Review Process Used

34. With TAC Secretariat approval, the Inter-Centre Review panel invited Centre representatives (CIP, CIAT, IITA, IPGRI, and IFPRI), technical experts, and a meeting facilitator to a three-and-one-half day workshop (May 30-June 2) held at the University of Maryland's Conference Center and Inn. Each of the IARCs was asked to prepare background documents, in a suggested format, that were to serve as resource papers for the workshop. Additionally, a "desk study" was prepared by the TAC Secretariat on production and consumption trends of the four main root and tuber crops (cassava, potato, sweet potato, and yam; see subsequent section for a discussion of these commodities). These sources of information were supplemented by the recently complete EPMRs at CIP, CIAT, and IITA.

35. Donal O'Hare, of O'Hare Associates, Inc. was commissioned as the meeting's facilitator, to direct the workshop on the process of identifying the strategic issues, and for generating options appropriate to the collective needs of IARC research on root and tuber crops. Following overview presentations by the five participating IARCs on the first morning of the workshop, the participants were asked to generate issues relevant to the terms of reference presented by TAC for the "stripe review," and in successive breakout sessions, to explore those issues through analysis and the generation of options, and to share those outcomes with the workshop in plenary session.

36. This process provided an opportunity for the Inter-Centre Review panel to interact directly with Centre representatives, and to obtain from experts independent opinions on topics relevant to TAC's terms of reference for the Inter-Centre Review. Additionally, the process provided the Centres an opportunity to share important and valuable information with the Inter-Centre Review panel, especially in reference to strategies and priorities within the CG system, *vis a vis* root and tuber crops. It was, however, clearly stated to all of the participants that the recommendations from the workshop represented advisory information for the Inter-Centre Review standing panel, with explicit statements that the panel would not be bound by the workshop's outcomes.

37. The Inter-Centre Review panel was particularly pleased with the energetic participation by all who attended at the workshop. This opportunity to focus on strategies and priorities for root and tuber crops research generated an extensive amount of material, including EPMR reports for CIAT, CIP, and IITA that described current and future conditions for root and tuber crop research within the CG System, and in its partner institutions. This productivity was no doubt greatly enhanced by the excellent process facilitation of Donal O'Hare.

SECTION 2 - OVERVIEW OF ROOT AND TUBER CROPS

2.1 Commodity Perspectives[1]

38. The commodities that make up root and tuber crops in the CG System are cassava (*Manihot esculenta*), potato (*Solanum tuberosum*), sweet potato (*Ipomoea batatas*), yam (*Dioscorea spp.*), edible aroids (*Colocasia esculenta* and *Xanthosoma spp.*), and Andean root an tuber crops (several genera).

39. Root and tuber crops provide a substantial part of the world's food supply, and are also a important source of animal feed and industrial products. On a global basis, approximately 45% o root and tuber crop production is consumed as food, with the remainder used as animal feed or for industrial processing for products such as starch, distilled spirits, alcohol, and a range of minc products.

40. The pattern of root and tuber crop utilization varies considerably among countries. In th developing countries (with the exception of China and Brazil), relatively small amounts (less thar 20%) are fed to livestock. Most of the remainder is used locally as food. The relatively high cost of transportation, processing, and storage, as well as the considerable time needed in food preparation, frequently makes unprocessed root and tuber crops less attractive to urban consumers.

41. The consumption of root and tuber crops as food in developed countries is considerably smaller than it is in developing countries, but their use as animal feeds is relatively higher. A ver small proportion of root and tuber crop production (approximately 5%) is traded internationally. More than two-thirds (2/3) of those exports come from developing countries, with Thailand's cassava exports accounting for more than half (1/2) of the total. Apart from cassava, only potatoes are traded internationally in significant quantities - mainly among developed countries.

42. There are considerable differences in the agroclimatic conditions suitable for the production for the different root and tuber crops studied by the CG System. Cassava is grown across a broad range of agroclimatic conditions from sea level to 1,800 meters, and from areas with as little as 500mm of rainfall, to tropical rain forest areas with more than 2,000mm per yea Potatoes, on the other hand, are considered to be a high latitude/altitude crop, originating in the Andes, but now grown in a range of environmental conditions, from traditional ranges to warme drier areas, including irrigated production in Latin America, Asia, and portions of Africa.

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[1] Much of the information contained in this subsection was derived from a TAC desk study of these commodities. Unfortunately, the TAC desk study arrived too late for inclusion i the materials for workshop participants.

43. Sweet potato is also understood to have originated in the Americas (as did cassava and potato), and it too is grown over a considerable range of latitude and elevation (up to 2,500 meters). Conversely, yams have a relatively narrower range of production, being mainly confined to the tropical region throughout the world from sea level to 1,400 meters. The main production of yam is in the savannah region of West Africa, where more than 90% of the crop is grown. Unlike cassava, potato, and sweet potato, the white and yellow yam (*Dioscorea rotundata* and *D. cayenensis [esculenta]*, respectively) are thought to be indigenous to West Africa, whereas the water yam (*D. alata*) is thought to have originated in Southeast Asia.

44. Most of the cultivated edible aroids are well adapted to high rainfall (and occasional flooding) and can be cultivated in temperatures ranging between 16° and 30° C, at elevations up to 1,600 meters.

45. The lesser-known Andean root and tuber crops, of which there are more than a dozen, vary considerably in their ranges of adaptation and tolerance to environmental conditions. They are primarily considered to be medium-to-higher elevation crops of moderate temperature regimes and water requirements, and have greater tolerance to frost than do other root and tuber crops.

46. According to the TAC Secretariat desk study, annual production growth rates to the year 2010 for root and tuber crops are expected to be positive, with the exception of modest declines in cassava in Asia (including China; -0.4%) and sweet potato and yams in Northeast and North Africa (-1.0%). TAC also predicts a decline in area for potatoes, cassava, aroids, sweet potatoes and yams in Asia (including China) over the indicated period (potatoes, -4.9%; cassava, -1.3%; aroids, -1.1%; sweet potatoes and yams, -0.2%).

47. Indicated changes in yield in the TAC Secretariat report are all positive, with the minor exception of a decrease in yield in Northeast and North Africa for sweet potatoes and yams (-0.7%). Significant yield increases are anticipated for potatoes in sub-Saharan Africa and Asia (including China), cassava in sub-Saharan Africa, aroids in Asia (including China), and sweet potatoes and yams in sub-Saharan Africa as well as in Asia (including China).

48. Some of the indicated changes will likely be driven by consumption demands and production opportunities as a result of technology yet-to-be-developed for root and tuber crops. Some of these technologies will no doubt entail food processing technologies, expanded feed markets, as well as current and new industrial uses for the harvested products of root and tuber crops.

49. The TAC Secretariat desk study traces historical changes in food, feed, and industrial uses of root and tuber crops, by commodity and region. Patterns indicate significant change is apparently taking place in the utilization of root and tuber crops, particularly with cassava and sweet potatoes in Asia (both in China and elsewhere), and in Asia for potatoes as both food and feed crops. The latter trend is primarily in China.

50. Total root and tuber crop consumption increased for developing countries (1980-1992) while per capita consumption declined over the same period, primarily with the exceptions of potato (+ 0.9%) and yams (+5.5%). When these patterns are examined regionally by commodity, it is clearly evident that the total consumption of root and tuber crops is increasing in Africa with annual rates of change for potato and cassava of +0.32%, and of yams a surprising +8.5%. Despite these increases in total consumption, per capita consumption patterns in Africa are lagging, likely as a consequence of increased population. The striking exception to this pattern is for yam per capita consumption of which in Africa increased +5.2% over the fourteen-year study period.

51. With a few notable exceptions, per capita consumption of root and tuber crops in South America and Asia declined over the period of the study, with some notable changes. Declining per capita consumption of sweet potatoes in South America (-2.7% per annum) was out-paced by the change in Asia (-5.2 %).

52. These patterns, derived from a TAC desk study, appear to be at odds with information provided by the relevant IARCs for their mandated root and tuber crop commodities. Consider the following points:

- For the past thirty years (from 1961-63 to 1991-93), potato production in developing countries grew rapidly. Annual growth was particularly strong in Asia (+3.9 % annually), and in Africa (+4.2%). Growth in production was combined with a continuing decline in the use of potatoes for animal feed in developed countries. Therefore, the share of global production in developing countries rose from 10% to 30%. By the early 1990s, developing countries accounted for 36% of the area planted in potato worldwide, up from 16% at the beginning of the thirty-year period. These patterns are expected to continue into the future at a projected rate of +2.7 % per annum in developing countries, reaching 105 million tons (for 34% of world production) by the year 2000.

- During the same thirty year period, world cassava production has experienced strong growth, with an annual rate of +2.7%, although this pace has declined during the past decade to +1.8% per annum (which does not keep pace with population growth). There are also differential patterns by region, but, for the most part, increased world production of cassava during the last decade has been mainly due to an area expansion (+1.7% annually) rather than increased yields. However, survey data gathered by the Collaborative Study of Cassava in Africa (COSCA) estimate cassava yields of 12 tons per hectare, as compared with FAO estimates of 8.5 tons. This difference indicates that yield increases may have been contributing more heavily to cassava production growth than other reports suggest.

- Processed cassava for human consumption is projected to play an important role in rural and lower- to medium- income urban populations' daily energy diets. This will be especially true in Africa, where cassava continues to play an important role in food security. Future cassava production levels are projected to be consistent with patterns of the past decade, which implies that the largest share of additional cassava supplies will continue to be derived from the African continent. Predicted patterns of cassava production in Latin America and Asia indicate continued growth of production at modest rates.

- The evolution of cassava from a basic world staple crop to a diversified end-use carbohydrate source has largely been completed in Asia, and is underway in Latin America. In Africa, while traditional processing techniques were integral to the adoption of the crop, agro-industrial transformation appears only to be in the beginning stages.

- Production growth rates of yams in West and Central Africa, where they are an important food staple, are surpassed only by rice. For example, yam production increased by seven million metric tons (20 to 27 million tons) between 1988 and 1993. The demand prospects for yams appear particularly positive, given expected economic growth and rising household incomes in the region.

- In China, where approximately 85% of global sweet potato production is grown, multiple uses of the crop (e.g., as animal feed as well as processing of the roots into starch, noodles, and alcohol), has helped to diversify markets for what was once mostly a directly-consumed food crop. In other regions, sweet potato use has declined or stagnated over the past thirty years. There are, however, some exceptions to this general trend. In sub-Saharan Africa, sweet potato production and area planted has not declined. Globally, in the poorest developing countries, and particularly in those areas affected by civil war, sweet potato production area has substantially expanded, a testament to its attributes as a human food during periods of famine and suffering.

53. There are, thus, discrepancies in not only the numerics of production and consumption of root and tuber crops, but also in the interpretation of exactly what the numbers mean, and how this information ought to be used to plan research strategies and set priorities for resource allocation. The panel took this divergence of opinion as an opportunity to reassess the strategies and priorities for roots and tubers from an inter-Centre perspective.

2.2 Research Accomplishments

54. To set the stage for assessing strategies and priorities for root and tuber crops research, the Inter-Centre Review panel inventoried CGIAR's accomplishments in root and tuber research. This provided some interesting background information that pointed out the very significant contributions that the CGIAR Centres have made to these crops.

Cassava (IITA)

- Collaborative studies, through a network (COSCA) in Africa, have examined varietal needs of farmers and the potentials for production, processing, and distribution. One anticipated outcome of the studies, namely to improve the relevance of research on cassava at national and international levels, was fully realized. For example, the description across several countries and socio-economic domains of preferred varietal characteristics at farmer, processor, and consumer levels has had a major input to priority setting in breeding programs.

- The characterization and integrated control of pests and diseases of root and tuber crops in Africa has led to a special focus on the biological control of cassava pests, including a remarkably successful Africa-wide biological control effort for the cassava mealybug.

- The genetic base of cassava has been expanded through varietal releases in a number of countries in sub-Saharan Africa. Most of these cultivars carry resistance to mosaic virus, mealybugs, cassava green mite, and cassava bacterial blight.

- Successful wide-crossing of cassava with its wild relatives has been accomplished to acquire genetic resistance to certain pests and diseases.

- Post-harvest research has solved, to a considerable extent, the problems of cyanogenic glycosides in cassava, thus helping to reduce prussic acid problems in the leaves and roots.

- Assemblage and maintenance of a significant collection of cassava germplasm of more than 2,000 accessions, consisting mostly of African farmers' cultivars and some exotic materials from Latin America, including roughly 200 accessions of wild manihot species from Brazil.

- Diagnostic capability for reliable screening for African cassava mosaic virus (ACMV) has been developed. This has enabled routine indexing of elite materials for distribution to NARS, and has facilitated the international movement of elite ACMV resistant clones to Latin America.

- A better understanding of ACMV etiology and epidemiology has been achieved, enabling control strategies to be improved in West Africa.

Yam (IITA)

- The acquisition and maintenance of more than 2,800 accessions of yam comprising eight cultivated species and several wild relatives, with accompanying agrobotanical and biochemical characterization.

- The genetic improvement of yam became possible through the discovery of how to induce flowering, which -- for the first time -- permitted conventional plant breeding.

- The elaboration of a minisett technology appropriate for use by yam growers, which vastly improves the multiplication ratio, and therefore the supply, of vegetative planting materials. The technique has been adopted by seed yam producers in West Africa.

- Studies of little known viruses in *Dioscorea spp.* and the development of an indexing protocol for *D. rotundata* has enabled germplasm distribution regionally and internationally.

- The development of micropropagation techniques for producing virus-free minitubers which meet quarantine requirements and enable the routine transfer of elite materials to national programs.

Sweet Potato (IITA)

- From 1977 to 1988, when IITA passed responsibility for sweet potato improvement to CIP, a sizeable amount of breeding stock was developed and distributed as virus-free plantlets to national programs worldwide. By 1988, at least fifty improved clones, based on IITA germplasm, had been officially released.

Aroids (IITA)

- A treatment was identified and refined to induce flowering in the edible aroids, thus removing the bottleneck to selective hybridization and genetic improvement of this plant group.

General (IITA)

- Partner institutions have been strengthened for enhanced global and regional scientific participation, including helping to establish more than twenty national root and tuber crops research programs in Africa.

Cassava (CIAT)

- Development of cassava information services as resources for professional enrichment of cassava scientists.

- Assemblage and maintenance of a world germplasm collection, representing 80% of the total diversity of cassava, complemented with related wild species.

- Methods for the *in vitro* conservation of cassava germplasm.

- Morphological and biochemical characterization of collected cassava germplasm.
- Global germplasm conservation and distribution.
- Ecoregional approach to gene pool improvement in cassava.
- Broad-based and durable resistance to major insects, mites, and pathogens incorporated into cassava gene pools.
- Characterization of the mechanisms of drought tolerance in cassava.
- Understanding and describing the C_3-C_4 intermediate biochemical characteristics of cassava photosynthesis.
- Identification of several effective biological control agents for major pests of cassava.
- Characterization of the post-harvest physiology of cassava roots.
- Improvement and local adaptation of cassava selections for food and industrial processing.
- Co-development of cassava drying and processing plants in Central and South America.
- Research on cassava's best management practices led to an understanding of how to maintain long-term soil fertility.

Potato (CIP)

- Development of Integrated Pest Management strategies based on biological control for th Andean potato weevil and the potato tuber moth.
- Diagnostic field kits for the serological and DNA-hybridization assay of potato tissue to determine virus status - especially useful in developing countries.
- Development of true potato seed technology, which is now deployed in a number of countries.
- Development of potato late blight resistant varieties that are being used in East Africa and portions of South America.
- Identification, cleanup and widescale distribution of an Argentinean clone that is now grown on more than 150,000 ha. in China.

- Collaborative development of a highly saturated marker map of the potato genome and development of specific markers for virus and improved late blight resistance.
- Establishment of an R-gene-free population with durable late blight resistance.
- Deployment of an Argentinean-developed potato cultivar with resistance to virus and tolerance to drought, which is now grown extensively in China.
- Development of an *in vitro* assay system for the conservation of potato germplasm.
- Completion of eight impact studies on CIP's work in varietal improvement, IPM, seed technologies, etc., identifying returns on investment ranging from 26-106% per annum.
- The acquisition and maintenance of an extensive collection of germplasm, comprising wild and weedy species, cultivars, improved varieties, and important breeding lines.
- Utilization of the "hairy potato" for resistance to potato insect pests.
- Bacterial wilt disease management strategy now being used in East Africa and Central America for effective disease control.
- Widespread utilization of CIP-released potato cultivars in Eastern Africa.

Sweet Potato (CIP)

- Production of improved sweet potato varieties now widely used in Peru.
- Development of an Integrated Pest Management system for sweet potato weevil that is now being used commercially in Cuba.
- An impact study of IPM of sweet potato.
- The collection and maintenance of a sweet potato germplasm bank (6,522 accessions).
- Development of methodologies to induce sweet potato flowering and seed set for germplasm conservation.
- Development of *in vitro* storage systems for sweet potato germplasm.

Lesser-known Andean Root and Tuber Species (CIP)

- Genetic conservation of nine Andean species of edible roots and tubers that are presently being evaluated for their agronomic characteristics, nutritional value, and potential for production and consumption.

55. The panel notes these achievements in root and tuber crops research with an appreciation of each individual Centre's success and with a view to the terms of reference of the Inter-Centre Review that asked for an evaluation of the opportunities and potential for inter-Centre collaboration. To undertake this evaluation, the panel gave focus to the similarities and dissimilarities of root and tuber crops in an attempt to find points-of-intersection that would permit synergies through inter-Centre collaboration.

2.3 Similarities and Dissimilarities

56. Root and tuber crops, which produce edible underground storage organs, share the characteristic of being vegetatively propagated. In addition, these crops all have a relatively short storage potential in comparison to cereal crops. These characteristics contribute to the difficulty of root and tuber crop production in the following ways.

57. Vegetative propagation significantly increases the potential for the spread of plant pathogens, particularly viruses, which in turn leads to tight phytosanitation regulations, extremely complicated "seed" production systems and the difficult distribution of planting materials. These constraints need to be considered when a strategy for the development and deployment of new cultivars and technologies for root and tuber crops is devised.

58. Another identified similarity of root and tuber crops relates to the needs and requirements for the conservation of their genetic resources. For each of the root and tuber crops a complementary approach to conservation involving a mix of different methodologies (primarily *ex situ*) would be appropriate, involving a field genebank, *in vitro* conservation, seed and pollen storage and storage of vegetative propagules. *In situ* conservation, (e.g., on farm) will have some limited applications. Field genebank conservation is costly and carries risks. Moreover, the requirements, particularly for the latter approach, and *in vitro* conservation, vary from crop to crop. These issues are sometimes not fully understood during the allocation of resources for this important area.

59. The second commonality of root and tuber crops is their perishability, which, depending on the commodity, can vary tremendously. Cassava and sweet potato can be "field stored" in the ground for a few months with minimal loss of quality if conditions are right. All of the crops have the distinct disadvantage, following harvest, of limited storability, and are fairly perishable if the conditions are not suitable. This characteristic of root and tuber crops predetermines the need for post-harvest treatment of these crops to preclude very large post-harvest losses.

60. The production and harvest of crops which produce edible underground storage organs are generally labor intensive. The sheer bulk of root and tuber crops, compared to cereals, is a bigger problem even that their underground location. Root and tuber crops can be harvested by means other than simply digging up individual plants (e.g., ploughs, spinners, mechanical harvesters) but the volume to be dealt with (stored or transported) remains a problem. The processing of traditional products from these crops can also require high labor inputs. In many countries, women are heavily involved in these tasks, so the role of women is worthy of special attention.

61. From a market perspective, root and tuber crops share some similarities at the farm level, but these characteristics become quite dissimilar from an off-farm market perspective. For instance, much of root and tuber crops production is consumed on-farm, or where distances are relatively close to production. Root and tuber crops produced for off-farm markets can have considerable dissimilarities in transportation, storage, processing, consumption, economics, consumer demand, and other factors. These differences need to be taken into account when inter-Centre opportunities are assessed for improving root and tuber crops, and for distinguishing among strategies for their improvement *vis a vis* the mission of the CG System. In fact, some individual root and tuber crops are presently experiencing a division of markets that will undoubtedly require substantially different types of cultivars to meet divergent market needs. Some examples of this phenomenon are the emerging uses of cassava as an industrial raw material, as compared with its traditional uses as a food. Similar differentiation is occurring with potato and sweet potato.

62. Root and tuber crops share similarities at the national program level, wherein for most NARS the capacity for research on these commodities is small, relative to other commodities. Commonly one researcher has responsibility for more than one crop (e.g., cassava and sweet potato). This situation places increased demand on IARCs to work on root and tuber crops in ways to assist national programs through partnerships that are oftentimes unbalanced.

63. Biotechnology represents an area of similarity for root and tuber crops because it can provide new research tools for the identification and elimination of viruses, the propagation and conservation of plant materials, and genetic enhancement. These similarities illustrate the opportunities the Centres have for biotechnology research collaborations among root and tuber crops.

64. Finally, one of the greatest similarities among root and tuber crops is unrealized yield potential that could be attained through yet-to-be-developed technologies. The panel chose not to use the term "yield gap" for this concept, as yield gap has been used to describe crop production levels that could be increased using known technology. In the case of root and tuber crops, the potential yield is considerably higher than the actual yield in many settings. All too frequently, the technology is not available to deal with yield-limiting factors (water, nutrients) and yield-reducing factors (disease, pests), but returns to research on these factors is expected to be much greater than on attempts to increase the physiological yield potential of cereals.

65. There are, however, in addition to the dissimilarities noted above, some additional dissimilarities that distinguish root and tuber crops. To scientists familiar with the biology of the root and tuber crops, the genetics of these crops are enormously dissimilar, as are the pests and pathogens that attack them and reduce yields. From a superficial inspection, it is true that the breeding of root and tuber crops is primarily done sexually, and that viruses, bacteria, fungi, insects, and mites attack these crops to varying degrees. The reality is that each of the pollinating systems and different ploidy levels brings with it breeding complications, along with specific opportunities for genetic development. The pest and pathogen complexes of root and tuber crops are remarkably dissimilar, in that none of the viruses of one root or tuber crop can attack another. Knowledge of one pest or pathogen may be generally applicable to other situations in other root and tuber crops, but the specific information cannot be directly applied. This is an important consideration, in that the transfer of developed technology is just as difficult from cassava to potato as it is from sweet potato to wheat.

66. Another dissimilarity of root and tuber crops is the properties of the starches that are produced in the harvested roots and tubers. There has been a limited amount of work on the characterization of root and tuber crop starches (mostly for potato, and to a lesser extent for cassava and sweet potato) but work to date has shown considerable variability within and between the crops evaluated. However, the methods required to evaluate the quality characteristic and assess the product potential are similar for any starch source. In addition, the primary processing technologies (flour/starch) required are also similar for all root and tuber crops. This information gap represents a whole new area of research that needs to be addressed if post-harvest technology of root and tuber crops is to become a reality. How much of this research should be done by the public sector and/or the CG System is addressed later in this report.

67. There are significant differences, and perhaps gains as well, in the farming systems of root and tuber crops ranging from contrasting systems of production for some crops to complex systems of intercropping involving two or more root and tuber crops. All of these aspects are important considerations, inasmuch as the transfer of know-how from one farming system to another is difficult, if not impossible. This, then, means that most farming systems research must be done for each root and tuber crop, thereby giving the appearance, falsely, of duplication of effort.

68. Strategies for the genetic improvement of root and tuber crops differ significantly since they have to take into account the various production systems and end-uses. Some crops (e.g., sweet potato, potato) may benefit from breeding cultivars adapted to shorter growing seasons, while other crops (e.g., cassava) may need to fit into different and contrasting growing cycles. Other considerations such as crop and soil management practices, crop rotation schemes, rainfall patterns, and similar operations drive decision making in breeding programs, making them unique to the crop, rather than to the group of crops classified as root and tuber.

69. The policy environment for food crops differs and some are often disadvantaged crops as a consequence of historical choices, political realities, and a host of other considerations driven by market demands, alternative foods, and substitute uses. Many of these policy factors are poorly understood for root and tuber crops, and later in this report there is a proposal for dealing with this point of dissimilarity.

70. The quantity and quality of available research generated from sources other than the CGIAR is another dissimilarity between root and tuber crops. For instance, potato research at developed country institutions is quite advanced, and currently there are activities in a number of areas that are being tapped by CIP. This is not the situation for cassava and yam research. And, to a degree, there is little Advanced Research Organization (ARO) technology available for sweet potato. There is virtually no research activity of potential benefit for the aroids or for the lesser-known Andean root and tuber crops, (beyond the CG System), that Centres could adopt from alternative research suppliers.

71. There are, though, clear similarities and dissimilarities that must be considered in evaluating the opportunities for joint research strategies for root and tuber crops within the CG System. Given these considerations, the panel elected to evaluate the opportunities for inter-Centre research collaborations on root and tuber crops research that would enhance efficiency and provide desired impacts. Each of the following items was built around the similarities of root and tuber crops previously identified.

- Post-harvest research on perishability, storability, starch quality, food processing, and animal feed.
- Plant propagation technologies to develop enhanced or new "seed" systems for the deployment of improved cultivars (one notion was to evaluate the potential for artificial or synthetic seed as a substitute for vegetative propagation).
- Conservation of genetic resources "*in situ*" and "*ex situ*"
- The development of human resources, including training, in several areas to support the mission of root and tuber crops research.
- Information and documentation for institutional partners.
- Biotechnology (to use the tools of molecular biology for genetic markers, cryopreservation, genetic transformation, and gene isolation).
- Build on existing institutional research networks.
- Research networking to bring into the extended research systems those regions and institutions that have not received appropriate degrees of attention or strengthening (e.g., weaker NARS, island nations).

72. Given this background of information, the panel involved the workshop participants in an analysis of the current and preferred situations for inter-Centre collaborations in root and tuber crops research. The next section provides the panel's evaluation of that analysis.

SECTION 3 - EVALUATION WITH RECOMMENDATIONS

73. The panel elected to conduct an issues-based evaluation of the strategy, operations, and organization of root and tuber crops research in the CG System with an inter-Centre perspective. In this multi-step process, the panel evaluated the current strategies that are being used by the participating Centres for root and tuber crops research. This, then, was evaluated against the operations of the institutions and the organization of activities, to determine current suitability and the indicated need for change.

3.1 Current Strategy, Operation and Organization

74. It is apparent that there does not exist today an inter-Centre strategy for root and tuber crops research. The panel could find no written documentation or any claims for a clear statement on a strategy for inter-Centre root and tuber crop research beyond the considerable scientific collaborations that exist between programs within the CG System. The panel was impressed by the number and variety of apparently spontaneous, ongoing collaborative efforts between Centres in root and tuber crops research. But these appear to be informal structures based on scientific desirability rather than on a strategy for root and tuber crops research.

75. The present root and tuber crops portfolio has been largely determined historically, during a period of growth in which Centres took on responsibilities as decisions made by their management and their boards.

76. Overall, the initial approach to root and tuber crops research seemed to relate to a common vision of a hungry world wherein these crops could contribute to famine relief. Nutritio and poverty considerations were introduced later. More recently has come the notion of "income generation" through root and tuber crops production and processing.

77. In the case of research-weak NARS, one peculiar consequence for root and tuber crops i that some of the Centres have developed a kind of autonomous research agenda, with a heavy emphasis on institutional strengthening through training and technical assistance. This is apparently an attempt to bring the NARS in as "junior partners." It is understandable, but it is a complicated and difficult strategy for the Centres that pursue it.

78. The perishability of the root and tuber crops has also complicated CG System research strategies by leading to greater investments in post-harvest technology, relative to cereal programs. Similarly, the difficulties of vegetative propagation have led to relatively larger investments in "seed technology" *vis a vis* what is allocated to seed issues in other CGIAR commodity programs, in an apparent attempt to assist NARS in obtaining research impact.

79. Interestingly, in recent years the CGIAR strategy has increasingly stressed the need for inter-Centre collaboration. Such collaborations must, in the panel's opinion, be built on a clear understanding of the biological similarities of the crops, especially for the frequently misunderstood root and tuber crops, if the expected benefits of collaboration are to be obtained.

80. It is noteworthy that each of the Centres working on root and tuber crops research has built strong upstream links with AROs as part of its institutional strategy for research with root and tuber crops. This may represent a special opportunity for interlinking AROs in an inter-Centre strategy for root and tuber crop research.

81. The mode of operation for root and tuber crop research within the CG System is still largely based on self-contained, independent operations, rather than as full-fledged partnerships among IARCs and with NARS.

82. The organizational structure (i.e., coordinating mechanism) of root and tuber crops research is "Centre oriented" and is not program-based. Any semblance of a system-wide root and tuber crops research program is simply the summation of related activities across autonomous Centres. One exception is the cassava program that is operating quite well between IITA and CIAT. This inter-Centre organization for collaboration in cassava research probably reflects to a great extent the willingness of scientists to work together to achieve a common goal, rather than some organizational structure to facilitate inter-Centre collaboration. In the panel's observation, there are no systems in place that would facilitate inter-Centre research on root and tuber crops within the CGIAR mandates.

3.2 Issues Analysis

83. Given these considerations, the panel (with the assistance of the workshop participants) analyzed six overarching issues relative to Inter-Centre research on the root and tuber crops. These six issues[2] were:

- Global planning and organization within the CG System
- Germplasm and vegetative propagation
- Biotechnology research
- Post-harvest and market research

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[2]The criteria that we used to identify the issues to be analyzed required that the topic be specific to root and tuber crop research; not duplicative of other system-wide programs; apply to more than one IARC; and represent, at least to a degree, some issue of programmatic responsiveness. Also, inasmuch as change is now going on in the CG System, proposed issues were expected to be relevant to the efficient use of resources; and related to high impact, and/or value as research results. Finally, the proposed issues were to be judged for applicability to the terms of reference that established this Inter-Centre Review.

- Partnerships
- Policy research

3.2.1 Global Planning and Organization Discussions at the workshop clearly indicated that root and tuber crops research suffers because of difficulties in global planning and priority setting for research, especially for assessments which build on important similarities and dissimilarities between the crops. Also lacking is an effective way to organize and conduct research on root and tuber crops which often are studied by a small number of scientists located in widely dispersed locations and institutions; including IARCs, AROs, and NARS in developing countries. Because funding for support of root and tuber crops research is unlikely to increase significantly in the medium term, these crops will require new or improved approaches to global planning, coordination, and partnerships for achieving critical mass in research.

84. The panel concluded that it should make one general recommendation for root and tuber crops research, upon which the remaining recommendations are based.

85. The panel recommends that an Inter-Centre Consultative Committee on Root and Tuber Crops Research be formed for system-wide planning, coordination, and operation.

86. This Committee's activity should be carried out with a regional and global perspective. The participating Centres should seek new forms of strong collaboration with one another, the private sector, AROs, universities and NARS, to achieve a critical mass in research to solve global or continental problems.

87. The panel evaluated, from three perspectives, new approaches that could be taken for inter-Centre collaboration and partnerships in root and tuber crops research. This analysis was undertaken to provide a perspective to the preceding recommendation, and to establish the boundaries of expectations that surround the standing panel's analysis.

88. From the first perspective, the panel asked, "if the System were starting all over again with root and tuber crops research, what would be the preferred strategy? This "clean slate" analysis led to the conclusion that it is very likely that the same root and tuber crops would be selected for research, and that the assignment of crops to Centres would remain the same. One exception might be a reassignment of mandates for cassava (see later section in this report on this topic). But the benefits of making such a total "fix" at this point might be very small. The panel concluded that a major "reengineering" of the CG's root and tuber crops research organization would not necessarily provide 1) a new strategy, 2) increase efficiencies, or 3) enhance opportunities for success. The clean slate approach was thus abandoned.

89. The second analytical approach which the panel undertook was to examine a rearrangement of commodities to see if a reorganization through a reassignment of commodities might yield some benefit. Again, the panel's analysis showed there were no significant scientific or management benefits to be gained from the reassignment of commodities among the participating Centres.

90. The third analytical approach that the panel used was to ask, "Could some new structures be formed that would facilitate inter-Centre collaborations on root and tuber crops research?" Through this analysis the panel did identify opportunities for:

- Enhanced planning and communication.
- Potentially greater operational efficiency.
- Better identification of common projects that could be jointly initiated through the participating Centres.

91. Some of the potential inter-Centre collaborations identified and recommended by the panel included joint projects on:

- Biotechnology.
- Collaborative efforts on germplasm movement strategies.
- The propagation and introduction of improved germplasm.
- Collaborative efforts on post-harvest and market research.
- Studies on international trade.
- Concerted collaborative efforts on strengthen national programs.
- Support for the system-wide genetic resources program, all with special reference to the root and tuber crops.

92. The panel recognized that it would be possible under existing mechanisms for individual scientists to identify and go stralght to these special topics through various forms of collaboration. In fact, nothing institutional would be likely to stop them. The panel's concern, however, is that some topics might not be initiated because of a lack of recognition, or the failure of the right personalities to come together to form an initiative. Therefore, the panel's preferred approach is for the creation of the proposed Inter-Centre Consultative Committee made up of the Directors General of CIP, CIAT, IITA, and possibly ISNAR, IPGRI, and IFPRI (or their designated representatives) to meet periodically to explore inter-Centre collaborative initiatives.

93. The system-wide interest in devolving commodities or research areas to national programs (eg., sweet potato to China; yam to Nigeria) could benefit from study by an Inter-Centre Consultative Committee. As noted above, there are numerous considerations that need to be resolved. This should be done with a system-wide perspective, and with an understanding of the similarities and dissimilarities of root and tuber crops within the CG System, taking into account the system's traditions of science quality, public service, and open access to knowledge and germplasm; and the funding implications of choices.

94. The panel also explored prospects for the co-location of Centre activities in African countries as a model. There are some significant difficulties that are not a first glance apparent. For example, IITA, CIP, and CIAT are co-located in Kampala, while CIP and IPGRI are both located in Nairobi. A superficial evaluation of opportunities to gain efficiencies within the CG System might suggest that individual Centres could "piggyback" on another Centre's existing Memorandum of Understanding (MOU), and thus expand operations, without much additional cost or commitment. This is not the case, as the existing Centre MOUs tend to be highly specific for intended activities, and most are not applicable to the commodity(ies) of another Centre. For instance, CIAT's MOU for Uganda is specifically for beans, and thus serves no practical use to CIP or IITA. Nevertheless there are opportunities for Centres with existing MOU's to help other Centres, such as in the importation of a limited amount of equipment that is crucial to implementation of specific CG programs.

95. The formation of an Inter-Centre Consultative Committee could help explore opportunities to resolve situations such as these, and perhaps provide greater efficiency through joint planning and the sharing of facilities and people at distant locations (including the posting of international staff at NARS laboratories).

96. The panel does acknowledge some concern for adding yet another layer of "bureaucracy," and the attendant additional costs. The panel notes, however, that our recommendation is for a Consultative Committee, rather than a budgeted entity.

97. The panel suggests that TAC assign responsibility for developing the terms of reference for the Inter-Centre Consultative Committee, perhaps through a third party. The costs and benefits of the proposed mechanism for inter-Centre coordination should be carefully studied as well, to provide assurances that the benefits will justify the additional costs that will be needed to support the Consultative Committee's activities.

3.2.2 Germplasm and Vegetative Propagation The conservation, maintenance, improvement, and deployment of germplasm have traditionally been core activities of commodity-based IARCs. Vegetative propagation of root and tuber crops complicates greatly the preservation and distribution of pathogen-tested vegetative material. This is a particularly demanding requirement for an International Agricultural Research Centre.

98. To conduct the panel's analysis of this issue a number of assumptions were made. Many of these assumptions reflect the biological realities of the crops being researched, and the collective experience of distributing vegetatively propagated material in a number of different settings, for each commodity. In general, although there are some exceptions, centralized governmental and public sector-organized distribution systems for vegetatively propagated crops have considerable difficulty (Cuba is a notable exception). In many instances there are limited prospects for a strong private sector that supplies planting materials, although there is a demand which seems not to be met. Also, there is a limited scope for enhancing the techniques and

efficiencies of these supply systems. The exception to this point is the potential for the development of new methods for certifying the plant health status of vegetative materials. Methods for vegetative propagation of all of the crops are reasonably well developed.

99. What is the bottleneck in the multiplication and distribution of vegetatively propagated root and tuber crops? The panel evaluated this question and listed a number of options for the solution of the problem. These solutions included the development of some inter-Centre special projects perhaps involving ISNAR. The projects should be of limited duration, and in partnership with NARS and with selected private sector representatives, to address constraints to the distribution of improved root and tuber crops germplasm. The panel suggests that the setting of this research agenda should be through farmer participation both for variety selection and for research approaches to enhance the acceptability of the resulting methods and materials.

100. With respect to the preservation of germplasm of root and tuber crops the panel recognized the need for the Centres to collect, characterize, conserve, move, and use the available germplasm, recognizing the unique challenges presented by vegetative propagation. The panel evaluated this topic using a number of assumptions to develop some options leading to a recommendation.

101. The panel assumed that germplasm preservation activities will continue to be an important component of any IARC working on root and tuber crops. It would therefore be desirable to provide more effective and cheaper methods for the conservation of this germplasm through new technologies, such as cryopreservation. Root and tuber crops are particularly difficult to store, as they are more vulnerable to loss than are other types of crops (i.e., those that can be stored as true seed). The panel also assumed that plant pathogens, especially plant viruses, will continue to be a major hazard to the international movement of plant materials intended for research. However, the panel recognized that the new biotechnologies offer considerable hope for increasing the safety of international shipment of plant materials, especially through use of biochemical and molecular diagnostic kits to identify the plant health status of material, and by enabling the culture of plant parts free of pathogens.

102. Given these assumptions the panel deliberated two alternatives that could be used as a strategy for inter-Centre collaboration on phytosanitation issues *vis a vis* germplasm. The first strategy was characterized as a higher cost/low risk approach to obtain, through the development of a centralized facility, phytosanitary certification of germplasm in an inter-Centre effort for the CG mandated root and tuber crops. The higher cost would be for the development and maintenance of needed technology and for institutional support to maintain a centralized facility that would deliver low-risk international shipments.

103. The second option was characterized as a low cost/"higher risk" strategy to speed up the exchange of materials between countries, with an emphasis on intracontinental movement of materials. This strategy would entail the development of internationally acceptable, rational

phytosanitary protocols based on the best possible science, and arguing for a lowering of non-tariff trade barriers which all too often complicate international phytosanitary regulations.

104. The panels noted the first option (higher cost/low risk) has been successfully accomplished by the INIBAP Transit Centre in Belgium. There are, however, some hidden costs to INIBAP. Also, the panel noted that the volume of banana and plantain moving through the Transit Centre was considerably less than the expected volume for a hypothetical root and tuber crops transit centre. A root and tuber crops partnership with the INIBAP Transit Centre seems out of the question, as the existing space and facilities at the Katholic University of Leuven could not accommodate the anticipated volume that would be transmitted, and dealt with, in a fully operational root and tuber crops research system.

105. Another consideration noted by the panel is the lack of trust relative to the problems of international shipments of vegetatively-propagated material. This problem is not that widely understood, and is manifested as "double cleaning." Untrusting recipients of vegetatively-propagated materials once again clean materials, certified as pathogen-tested at the time of shipment. This becomes a double delay in the exchange of material that would not necessarily be resolved by the creation of a root and tuber crops transit centre.

106. The panel recommends that the proposed Inter-Centre Consultative Committee commission a task force to explore the possibility of rationalizing international phytosanitation regulations and institutional arrangements for shipments of root and tuber crops as vegetatively-propagated materials.

107. This activity could be done in partnership with FAO and IPGRI, which have experience in developing similar protocols for other commodities. This approach should work to speed up the exchange of germplasm for international research on root and tuber crops.

3.3.3 Biotechnology Research The panel noted the opportunities for the application of new tools of biotechnology to the genetic improvement and maintenance of healthy materials of root and tuber crops. In the panel's assessment, these applications need to be stimulated within the CG System, particularly when working in partnership with non-CG institutions. This effort will require, however, adequate resolution of several outstanding issues, such as: claims to intellectual property rights; biosafety compliance; access to genetic materials; and the use of material transfer agreements. Some of the lesser biotechnology- researched root and tuber crops, such as cassava, may require careful coordination of research activities to prevent double investments in this expensive area of research. Benefits should include incorporation of agronomically important genetic traits from foreign sources, marker- assisted selection, and genetic probes for plant pathogens. Inter-Centre coordination of biotechnology research on root and tuber crops should help to identify appropriate partners (AROs and NARS), share resources effectively; and better distribute advanced research methods.

The panel recommends that the proposed Inter-Centre Consultative Committee commission a study to recommend inter-Centre collaborations in biotechnology research.

3.3.4 . Post-harvest and Market Research The panel investigated the question, "What should be CGIAR's role and level of investment in the area of post-harvest and market research?"

108. The panel acknowledges significant inter-Centre collaborations in post-harvest and market research for root and tuber crops. Some important examples are:

- Product development workshops/manual (jointly by CIP, CIAT, IITA).
- Marketing methods materials in Spanish and English (involving CIP, CIAT, IFPRI).
- Demand studies for potato (Bangladesh, Pakistan) and sweet potatoes (Philippines) (done by CIPand IFPRI).
- Marketing research on root and tuber crops in China (CIP and IFPRI).
- FAO expert consultation on root and tuber crops for animal feed (involving CIP and CIAT).
- Evaluation of competitive position of sweet potato versus cassava in Vietnam and Peru with national program collaborators (CIP and CIAT).

109. There are appear to be, in the panel's estimation, opportunities for greater efficiency in post-harvest and market research that could be obtained through greater collaboration among Centres--and with AROs and NARS through partnerships.

110. In the panel's opinion, considerable opportunity exists for the development of improved cultivars for processing and for new processed products based on genetically-enhanced root or tuber quality and storage potential. This is, however, not a trivial consideration but one that demands considerable evaluation, analysis, and strategy. Moreover, it is likely that strong research partnerships with the private sector may be necessary in order for the private sector to engage successfully in post-harvest and market research with root and tuber crops.

111. In its analysis, the panel assumed that urbanization in the developing world will open up market opportunities for new food and non-food processed products that could be based on root and tuber crops. Significant commonalities appear to exist across root and tuber crops in the area of post- harvest technology and for research on the development of new products through post-harvest technology. This would likely lead to demand-driven root and tuber crops research to make those crops more competitive with other crops on the farm level, and for strategies to provide income for the producers.

112. Strategies to pursue these research opportunities were evaluated by the panel as options by which to formulate a single recommendation. Continuation of the *status quo* seems inappropriate because it would fail to capture the potential synergies that could be applied to the development of post-harvest technologies for root and tuber crops. Certain aspects of post-

harvest technologies will continue to require location-specific attention (at regional or sub-regional levels). Nevertheless, there could be gains in efficiency to be realized by conducting research on other well defined topics in a more centralized way.

113. The panel recommends that the proposed Inter-Centre Consultative Committee sanction a post-harvest technology and market working group to explore with AROs, NARS, and the private sector root and tuber crops research partnerships on:

- **The characterization of starch and flour (antecedent to industrial processing).**
- **Food processing technology.**
- **Market research.**

114. These studies might best be done through information-sharing initiated by a lead Centre.

115. The panel recognizes that undertaking this initiative may require additional resources (or the reallocation of resources), which seems justified given the importance of this topic.

3.3.5 Partnerships In stating its priorities and strategies, TAC noted the opportunities for partnership with research-strong NARS as an opportunity for Centres working on root and tuber crops. It is understood that the intent of this approach would be to improve research output for root and tuber crops by drawing on the capacity of NARS to conduct such research.

116. The panel evaluated this issue and concluded there were opportunities that could be pursued through inter-Centre strategies.

117. Clearly, the national programs have benefited tremendously from the CGIAR investments in root and tuber crops research. These benefits have been derived as increased incomes, greater food supplies, and enhanced capacity in national programs to conduct research on root and tuber crops. In spite of past capacity-building, many individuals at the Centres working on root and tuber crops feel that most developing country national programs lack the critical mass of scientific strength necessary to meet their own national research needs. Some have proposed that NARS research networks are a viable alternative to insufficient national "critical mass," and several positive examples of such networks exist to document the argument. It is likely that this assessment has led IARCs to invest in networks and partnership arrangements designed to strengthen root and tuber crop research within national program does not seem straightforward at this time.

118. Many of the shared characteristics of the root and tuber crops could make them difficult to handle (vegetative propagation, phytosanitation, storage, etc.). This factor, along with insufficient funding, appears to dissuade national research scientists from working on root and tuber crops. This factor presents a dilemma to the CGIAR system for the organization of

research partnerships. Although there are number of very successful bilateral partnerships and networks that are operational, the expectation for the direct devolution of a commodity or disciplinary area of science to a national program seems, at this time, not straightforward.

119. The panel conducted its evaluation of partnerships using a number of assumptions. The panel assumed that Centre budgets will remain constrained, and that funds will not be available to fully reimburse national programs for assuming major research responsibilities. It was additionally assumed that the budgets of potential partners would remain constrained. Research partnerships would therefore be based more on mutual interests, rather than on contract-for-research relationships with payment for services rendered. The panel does not expect national programs to underwrite international agricultural research projects of significant size.

120. The panel also assumed that developed countries are not likely to increase their interest in root and tuber crop research with the exception of potato, which is a commodity of interest to their region. The panel also assumed that the dissimilarities of root and tuber crops would contribute to the need for different types of partnership arrangements, especially with regard to research scope and coverage.

121. The panel's analysis led to a number of options that were evaluated for feasibility. Each of these supposed mechanisms for establishing inter-institutional linkages (such as networks or research collaborations) were evaluated by using specific examples identified as relevant to contemporary root and tuber crops research. After exploring a number of options it became apparent to the panel that the CG System needs to maintain considerable flexibility in the types of relationships that are established for conducting research on crops that have a number of dissimilarities, given the fact that a considerable breadth of research activity is needed.

122. The panel recommends that the proposed Inter-Centre Consultative Committee continuously explore opportunities for different types of partnerships and collaborations among IARCs, and with public and private partner institutions in both the developed and developing world.

123. This recommendation is made with the panel's acknowledgement of the fact that there is no one formula suitable for the "devolution" of research responsibility. Actions to form partnerships with "research-strong NARS" must carry with them unique considerations and organizations for programmatic needs. Also, it must be recognized that, justifiably, a NARS should receive funds to meet the marginal costs of internationalizing a part, or parts, of its national research program. This will require industrialized planning and multiple year budget commitments.

124. A model partnership with a research strong NARS to help solve some international problems is given for sweet potato. Produced on 6 million hectares annually, sweet potato in China is often grown on marginal lands, by very poor farmers, and is used for food, livestock feed, and processing into starch, alcohol, and noodles, plus other minor uses and products. CIP,

recognizing China's interest and research capacity in sweet potato, has included contract research with Chinese institutions as part of its core program. Like sweet potato, similar support for potato research is handled through CIP's regional office in Beijing. The panel congratulates CIP's liaison office for devising this partnership approach.

125. The panel considers the CIP/China partnership in potato and sweet potato as a point of departure for further collaboration. This approach would help Centres acquire critical mass in international research at lower cost and with strong NARS participation.

126. The panel recognizes that there are several principles that should be considered when establishing partnerships with stronger NARS that carry with them a higher level of international responsibility. Some of these include a willingness to share results of the partnerships with other countries and institutions, and a willingness to support and expedite shipment of germplasm into and out of the country. The panel also recognizes there may be other complications to a proposed research partnership: the sustainability of funding; intellectual property rights (IPR) questions on the derived materials; the possible need for material transfer agreements; and phytosanitary matters relating to germplasm movement (all of which are not, of course, exclusive to this type of partnership). The intent of the panel's recommendation is to have the Inter-Centre Consultative Committee provide continuous oversight to these and related issues.

3.3.6 Policy Research One of the potential areas of inter-Centre collaboration that was clearly evident to the panel entailed opportunities for policy research. During the course of the workshop, one of the breakout groups had opportunity to compose a list of potential collaborative research areas that could be conducted as an inter-Centre initiatives. Nine topics were identified as:

- Compare crop yield data with regional and national statistics to detect systematic biases and recommend improved methods for yield estimation in root and tuber crops.
- Fine-tuning of international projections of supply and demand for root and tuber crops.
- Indirect effects of distortionary sectorial policies and food aid on the production and consumption of root and tuber crops.
- Determine the role of public investments in infrastructure and transportation on production and consumption of root and tuber crops.
- Resource allocation to root and tuber crops research in the NARS.
- Impact and implication of CGIAR-related root and tuber research.

- The evaluation of the competitiveness of root and tuber crops as substitutes for internationally-traded commodities (i.e., cassava for feed versus imported feed grains; domestic production versus imported frozen foods; cassava starch versus imported starch), and the implications for research.

- Determination of the alleged relative inferiority (or superiority) as consumer goods of root and tuber crops in time and space, and the value of root and tuber crops as food security.

- Economics of processing of root and tuber crops and the role of the public sector and the IARCs.

3.3 Incentives for Progress

127. There are some incentives that could be provided to facilitate inter-Centre collaboration on root and tuber crops research.

128. The panel proposes that TAC could clarify the linkages of CG System root and tuber crops research programs to ecoregional and system-wide activities that are now being initiated.

129. The panel proposes that improved information on the present and future importance of root and tuber crops, and their contributions to the CGIAR goals of food security, poverty alleviation, and sustainability would help establish appropriate research roles and help set priorities for research on these crops. This might include the development of appropriate databases and geographic information systems to help decision makers plan strategies and set priorities.

130. In another dimension (and where appropriate), the Centres should develop joint partnerships and networks with NARS on a regional basis, and explore other arrangements with NARS, NGOs, AROs, universities, and the private sector on an inter-Centre basis.

131. The panel clearly sees opportunities for Centres to work cooperatively, to share capabilities (e.g., science discipline strengths) within regions, and to jointly respond to the needs and opportunities of NARS through a more coordinated effort on root and tuber crops research and training. This might be modelled after the successful CIAT/IITA cassava coordinating mechanism, that captures opportunities for complementarity, based on each other's capabilities.

132. Relative to the common difficulties of effective delivery systems for improved planting materials of root and tuber crops, the panel notes that the appropriate Centres could jointly engage in activities with other institutions such as FAO, the World Bank, and research-strong NARS for a concerted action program to resolve these constraints. Failure to find appropriate

solutions to these complex problems will severely restrict the potential for impact from current and future research on root and tuber crops. In the panel's view, a considerable portion of the research needed in this area must involve the social, behavioral, and economic disciplines.

133. Inter-Centre coordinated efforts in root and tuber crops could provide a clearer vision of how investments in research in these commodities could pay off, relative to other research investments. Several representatives from IARCs working on root and tuber crops noted to the panel the perceived underinvestments in research of tropical root and tuber crops. This underinvestment, it was argued, represents a missed opportunity in what one scientist called, "Phase I" technological change.

134. The panel reports this perspective not in its own defense, but in recognition of a group of scientists who feel that they have not been heard in the decision making process and priority setting activities of TAC. The panel concluded that there are significant differences of opinion on the potential for research to impact root and tuber crops production and consumption patterns. These differences seem to be traceable to different sources of information, methodologies, and interpretations.

135. One major difference that now exists regarding priorities for root and tuber crops research appears to be a discrepancy in vision. The panel carefully assessed this point in recognition of the fact that TAC is embarking on a new round of priority setting for the CGIAR system. The panel asked, "What can be done to ensure that root and tuber crops are given appropriate weight in the CGIAR vision, and that root and tuber crops research will receive in the future an appropriate priority?"

136. The panel recognized that the CGIAR system was initially cereals-driven, riding on the success of the Green Revolution. As noted earlier in this report, the "founding fathers" provided sufficient flexibility for the system to evolve through the addition of crops, such as roots and tubers.

137. The panel is concerned that the methodologies used by TAC in the next round of priority setting may not be fundamentally different from those in the last exercise. It was further assumed that the IARCs will have another opportunity for contributing information and views, to be taken into account as the priority setting process gets underway. Given these considerations, it seems appropriate that an inter-Centre vision of root and tuber crops research should be prepared to counter what is perceived by some to be biases within the system against these commodities.

138. The panel recommends that the proposed Inter-Centre Consultative Committee convene a task force, including non-CG members, to prepare a comprehensive, documented text that sets out a vision for root and tuber research employing inter-Centre collaborations and institutional partnerships for root and tuber crops research.

139. The panel believes that this approach would permit the participating Centres to address their "grievances" in an organized and scientifically valid presentation of information to assist in a positive way the priority setting process of TAC. The panel does not believe that this task would be onerous on the Centres, inasmuch as much of the information is readily available in documentation prepared for the Inter-Centre Review, and from the recently-completed EPMRs of CIP, CIAT, and IITA. The panel believes that this approach would give the Centres a deserved opportunity to obtain a balance on the roles of root and tuber crops research within the total efforts of the system through a vision restatement.

SECTION 4 - THE FUTURE

4.1 Preferred Strategy, Operation, and Organization

140. Under its terms of reference, the panel explored alternative approaches for carrying out research on root and tuber crops in the CG System. This was done by reviewing strategies, operations, and organization from an inter-Centre perspective to see if preferred arrangements could be identified. Much of the information that was generated evolved from the workshop, derived through breakout groups and plenary discussions. However, all of the information presented here represents the panel's assessment and consensus views on how inter-Centre collaboration on root and tuber crops research could be more effectively arranged.

141. The panel concludes that an inter-Centre initiative on root and tuber crops research, coordinated by the proposed Inter-Centre Consultative Committee, could develop a better strategy for enhancing their effectiveness, and would increase the likelihood for their success. Some elements seem necessary to bring this about.

142. In the panel's view, a clearly stated approach is needed for how research on root and tube crops could pay off, and how the benefits will flow for the alleviation of poverty and hunger, provide better food security, and yield additional farmer income. This should be approached as a common strategy that focuses on the similarities of root and tuber crops. This common-effort-approach should allow the development of collaborative research synergies among the IARCs, their partner institutions (including research-strong NARS), AROs, universities, NGOs, and the private sector.

143. An inter-Centre strategy for root and tuber crops research should provide a focus on targeted subjects that would amplify the investments of research resources by working across commodities, and thus multiply the resulting benefits. Earlier in this report, some of these common areas were mentioned, and they are repeated here for emphasis - post-harvest technolo and market research; biotechnology; policy analysis; vegetative propagation and conservation technology; and international germplasm exchange with phytosanitation.

144. It is clear, however, that some areas of research will remain best carried out separately b each Centre. Other areas of root and tuber crops research will be planned within a framework o an inter-Centre strategy. A third category of research will be those activities that should be promoted, but may need to be slotted into a wider strategy (e.g., biotechnology, IPM).

145. In establishing an inter-Centre strategy on root and tuber crops research, there will be a need to design appropriate training programs to support program priorities; provide services to supply information for global and regional efforts; and to find new ways of "doing business." These points provide additional justification for the proposed Inter-Centre Consultative Committee.

146. In the process of developing the concept of an inter-Centre strategy for root and tuber crops research, the panel needed to maintain an appreciation for the differential involvement of activities across root and tuber crops, based on our understanding of the dissimilarities the crops, regional differences, and technological opportunities. In recognition of this distinction, the panel developed the following table as degrees of emphasis on the root and tuber crops mandated within the CG System.

Preferred Levels of Commodity Research Activity[3]

	Cassava	Potato	Sweet Potato	Yam	Aroids
Germplasm	***	***	**	*	*
Genetic Enhancement	***	**	*	*	
Genetics and Breeding	***	**	*	*	
Testing	***	***	**	*	
Crop Management	***	**	*		
Plant Protection	***	***	**		
Natural Resource Management	**	**	*		
Village-level Processing	*	*	*		
Industrial-level Processing	**	**	**		

147. The lesser-known Andean root and tuber crops are not included in the table, as the panel recommends minimal activities concerning them (primarily focusing on germplasm conservation).

[3] Three asterisks indicate a high level of CG involvement, two asterisks indicate strong involvement, one asterisk indicates some involvement, and no asterisks indicates no activity recommended.

148. There is an intended order of increasing involvement in some areas of research, as the above table indicates for some activities. To accomplish this new level of research activity there is necessarily a need to decrease (i.e., downsize) other activities, given anticipated flat levels of funding. In the panel's judgement, these decreased levels of research activity are reflected in the table as lessened emphasis in the yam program (thus releasing resources for cassava research at IITA) and as a lessened emphasis on sweet potato (thus providing more resources for CIP to invest in potato research). These shifts would occur primarily as: less activity in yam and sweet potato genetic enhancement and breeding; reduced testing; and less crop management research, relative to current activities. Within other cells the nature of the work would tend to evolve in line with a closer collaboration of efforts, mostly with partners both within and outside the CG System.

149. The panel identified some potential changes in operations on root and tuber crops researcl from an inter-Centre perspective. The panel noted opportunities for streamlining the exchange of germplasm (including wild relatives), through joint efforts to improve the process, protocols, and technologies used for cleaning vegetative material. Related to this topic is the panel's suggestion for a joint research project on root and tuber crop reproduction biology, as a way to better assure the eventual adoption of improved materials. This research direction could search for alternative technologies to be used for the conservation and exchange of root and tuber crop genetic materia (e.g., cryopreservation; culture techniques; diagnostics; artificial seed).

150. The panel noted, from an operational perspective, that there are many opportunities for joint activities. For instance, joint projects could be used to conduct surveys in related areas of root and tuber crops. These surveys, coordinated as inter-Centre efforts, could bring savings, an yield tremendous benefit for the participating researchers by "piggybacking" questions on a common survey instrument.

151. The panel noted the desirability of improving operations with respect to NARS to provid a more rational and consistent process in the interaction of root and tuber crops research, than now exists. This would best be done through inter-Centre evaluation of current operations and the identification of preferred operations, some of which already are shared efforts.

152. As noted above, there are a number of opportunities for collaborative research activities that could be conducted jointly by Centres on topics common to root and tuber crops. Such specific research problems could be jointly addressed if better operational mechanisms were put i place to enhance inter-Centre projects (e.g., biotechnology, post-harvest technology, market and trade analyses, vegetatively-propagated crops, policy issues, phytosanitary constraints, starch biochemistry, germplasm collection and preservation, collection of statistics and surveys, trainin and mechanization research)

153. Successful implementation of a strategy for root and tuber crops research through specifi inter-Centre operations will require a suitable organization. One of the greatest needs, in the panel's view, will be for better coordination of activities among Centres. This might be done

through periodic meetings to discuss preferred organizational structures, the creation of coordinating mechanisms, the development of communication systems, the training of people, and an appreciation of institutional cultures that need to be brought together in a collaborative setting. The panel's earlier recommendation for a Inter-Centre Consultative Committee on Root and Tuber Crops Research should provide the organizational means for determining preferred approaches for root and tuber crops research in a variety of areas, many of which have been listed above.

4.2 Anticipated Benefits of Change

154. The panel attempted to evaluate the likely reception of changing approaches to research on root and tuber crops within and beyond the CG system. This receptivity was evaluated from the perspective of donors, NARS, farmers, Centres, and non-CG centres in an attempt to anticipate how they might view the panel's recommendations.

4.2.1 Donors

155. The panel believes that a concerted inter-Centre initiative on root and tuber crops research would provide better donor appreciation of the opportunities for research, and present a "cleaner" strategy for their evaluation. In the present climate, it is desirable for proposed research activities to have an anticipated impact. The panel believes that a clearly stated strategy for root and tuber crops research could include such *ex ante* impact assessments. Statements of impact should be developed, with the anticipated eventual payoffs, especially for the intended rural and/or poor populations. A clearly stated strategy could further elevate the visibility of inter-Centre collaboration (which is already respectable), and bring into the partnership more members, including the private sector.

156. The panel believes that the donor community may or may not be interested in post-harvest technology research as a major topic. Consequently, this may require a policy statement from the CG system to clarify the legitimacy of this strategic approach.

157. The panel also anticipates that donors might ask about the propriety of post-harvest technology research being funded in the public sector, and if there are not alternative suppliers in the private sector. The panel has concluded that this area of research has suffered underinvested for a considerable period of time, and that pre-commercial research through the CG System could initiate considerable opportunity and derived benefit, for both the farmers as the main client, and for the private sector as a catalyst, if carefully planned and strategically developed.

158. The panel also anticipates that donors to the CG System may expect of this panel a statement about the appropriateness of existing mandates for root and tuber crops research. The panel's response to this expectation is that the current mandates are, for the most part, working. A reconfiguration does not seem to be justified in our judgement.

4.2.2 NARS

159. The panel concluded that a new inter-Centre strategy for root and tuber crops research would boost the morale and enhance awareness within the NARS. This could result in closer partnerships with substantial scientific benefits. Some of these benefits might include: stronger research programs; more access to information; increased awareness of research opportunities; greater exchange of research materials; greater mobility of germplasm; better linkages to third institutions, including advanced research organizations leading to new partnerships; better training opportunities; and more exchange of research results.

160. The panel did not feel that an inter-Centre strategy for root and tuber crops research would be seen as a threat by the respective NARS.

4.2.3 Farmers

161. In the panel's view, enhanced inter-Centre research on root and tuber crops would increase opportunities for farmers, especially women and children, who are engaged in the production of root and tuber crops. The results of the proposed collaborative research on root and tuber crops to provide improved "seed" systems will have direct benefits to farmers by giving them access to healthier planting materials. Research on post-harvest technologies should provid increased market absorption of harvested products, and thus produce additional income for farms more food for consumers; increased rural employment when small-scale processing is available; and perhaps more industrial products. Greater partnerships derived from inter-Centre collaborations on root and tuber crops research should expand the use of research findings, and perhaps open new channels for feedback from the farm community, which would be useful for priority setting in areas such as germplasm preservation, variety selection, and research priorities.

4.2.4 Centres

162. The panel concluded that international Centres would benefit from an inter-Centre initiative on root and tuber crops through enhanced partnership opportunities and a new awareness of investments in root and tuber crops research. The proposed initiative could clarify roles among Centres, and provide increased attention to problems within and among commodities of the root and tuber crops group. Greater coordination of planning and implementation should increase the efficiency of research investments, and assist in the exchange of data and knowledge for the benefit of all.

4.2.5 Non-CG Centres

163. A concerted inter-Centre initiative on root and tuber crops research could have ripple effects within the system and beyond. In addition to facilitated cooperation and support, there should be an increase in the strength of research, and a consequent elevation of appreciation of the opportunities for research on root and tuber crops. Through a clearly stated research strategy there should be new opportunities for partnerships with the private sector, NGOs, AROs, and others. This should go a long way towards reducing what some have criticized as the autonomy and isolation of root and tuber crops research globally.

SECTION 5 - CONCLUSIONS

164. The panel feels that its overarching recommendation to form an Inter-Centre Consultative Committee for Root and Tuber Crops Research provides a "Pareto optimal solution" for the CG System's efforts. This assertion is based on the expectation that considerable synergies can be obtained from inter-Centre collaborations and new partnerships in carefully selected research areas. The operational costs should be minimal, especially when viewed relative to the anticipated research pay-offs, but this needs to be verified by more detailed study.

165 The panel was surprised by the extent of differences that apparently dominate discussions of priority setting for root and tuber crops research within the CG System. Many of these differences appear to be based on different sets of assumptions, insufficient production and consumption data, and too little exchange of information about the science and technology of root and tuber crops. Individually, the Centres feel disadvantaged, and in need of defending themselves from what they perceive to be incomplete information and bias against their commodity assignments. The panel has a degree of sympathy for the Centre's perspective, as factual information should be used to set priorities for the allocation of resources within the CG System. If better or more complete information can be made available to justify a different priority for root and tuber crops research, then there is an obligation for the CG System to encourage the discovery and assemblage of that information, inasmuch as the best decisions should flow from the best available information.

166 Even though the panel sees considerable opportunity for inter-Centre collaboration, this initiative will need the support of both TAC and the CG System if it is to succeed. The Centres appear willing to engage in specific collaborative research efforts, and they appear to be receptive to creating coordinating mechanisms to expedite these initiatives. There was true excitement at the Root and Tuber Crops Workshop for some of the specific research topics that were identified as strong candidates for inter-Centre collaboration. In some cases, there appears to be sufficient resources to begin some initiatives right away (e.g., policy analysis) but in other cases (e.g., post-harvest technology research), reallocation of existing resources, or perhaps even new resources, will be required.

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APPENDIX 1

WORKSHOP ON ROOT AND TUBER CROPS RESEARCH IN THE CGIAR

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APPENDIX 2

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APPENDIX 3

TERMS OF REFERENCE

INTER-CENTRE REVIEW OF ROOTS AND TUBERS RESEARCH IN THE CGIAR

The purpose of the Review is to assist TAC in formulating a Systemwide strategy for research on roots and tubers in the CGIAR to meet global and regional needs, taking into account current and projected demands. Specifically the Review will:

(i) Assess CGIAR priorities and its organization of work with respect to roots and tubers, considering them both as commodities and as components of production and farming systems.

(ii) Explore alternative approaches for carrying out this work.

Special consideration will be given to the following:

(i) Identify the major constraints on increased production and consumption of roots and tubers, including post-harvest problems, emphasizing those that have international research significance.

(ii) Review ongoing research and related activities on roots and tubers at CGIAR and other research organizations as well as relevant advanced institutions.

(iii) Outline priorities and strategies for roots and tubers research within the CGIAR, paying particularly attention to Systemwide aspects of research efficiency and impact potential.

APPENDIX 4

LIST OF ACRONYMS

ACMV	African Cassava Mosaic Virus
ARO	Advanced Research Organization
CIAT	Centro Internacional de Agricultural Tropical
CGIAR (CG)	Consultative Group on International Agricultura Research
CIP	Centro Internacional de la Papa
COSCA	Collaborative Study of Cassava in Africa
DNA	Deoxyribonucleic Acid
EPMR	External Program and Management Review
FAO	Food and Agricultural Organization of the United Nations
IARC	International Agricultural Research Center
ICRT	Inter-Centre Review of Root and Tuber Crops Research
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
INIBAP	International Network for Improvement of Bananas and Plantain
IPM	Integrated Pest Management
IPGRI	International Plant Genetic Resources Institute
IPR	Intellectual Property Rights

ISNAR	International Service for National Agricultural Research
MOU	Memorandum of Understanding
NARS	National Agricultural Research System(s)
NGO	Non-Governmental Organization
TAC	Technical Advisory Committee